PART : 3

CHAPTER : VI

KHADIR FORMATION - STRATIGRAPHIC CONSIDERATION

The Khadir formation as discussed earlier comprises a varied sequence of conglomerate, sandstone, shale, limestone and clay with a combined thickness of 319.9 m. and age range Bathonian to Oxfordian. Most of these sediments are of mixed Siliciclastic-Carbonate in nature. Marine fossils and trace fossils occur throughout the succession but are rare in some intervals. Plant debris and bored rock surfaces are locally abundant. The entire sediment sequence is subdivided by the author into eight stratigraphic units, each one being designated as a 'Member'. This subdivision is proposed on the basis of the stratigraphic position of the rocks, their lithic characteristics and the vertical and lateral distribution. All the lithological units so recognised generally confirm to the law of superposition and the recommendation of the International Code of Stratigraphic Nomenclature [1983].

In order to gain detailed information on the lithology and biogenic contents of individual members, stratigraphic sections were measured at 20 different localities. The location and other details of these sections are given in the following Table : 4.

Definition of each member is based on its field description, regional distribution including the details of its rock material, its vertical and lateral distribution. Boundaries of the units are placed at position of lithic change, distinct contacts and key-bed occurences. Brief description of all these members is attempted in the following paragraphs.

TABLE : 4

LOCALITY INDEX

SR. NO.	LOCALITY	LATITUDE	LONGITUDE
1	Chhariya Bet	24°56'15"	70°20'15"
2	Hadibhadang Pir	24°53'40"	70°22'25"
3	Hadibhadang Dungar	24°54'40"	70°21'35"
4	Umrapur	24°54'15"	70°26'25"
5	Gadhada	24°52'05"	70°22'50"
6	Vavdi	24°52'30"	70°20'40"
7	Ratanpur	24°51'30"	70°21'50"
8	Ganeshpur	24°51'05"	70°23'15"
9	Chamwa	24°52'40"	70°23'50"
10	Nathara	24°49'35"	70°23'50"
11	Bambanka	24°48'35"	70°20'05"
12	Janan	24°49'55"	70°18'20"
13	Shobharel R. [Chanpar]	24°51'35"	70°17'20"
14	Kalara Talav	24°48'00"	70°22'00"
15	Ratnasar	24°53'49"	70°21'12"
16	Jhinjhu Nadi	24°51'30"	70°23'25"
17	_____	24°51'14"	70°19'42"
18	_____	24°51'12"	70°22'20"
19	_____	24°54'45"	70°28'20"
20	_____	24°54'25"	70°26'30"

[1] CHHARIYA BET BRECCIO-CONGLOMERATE MEMBER [CBCM] :

The name of the member is proposed from its exposures studied at the oblong shaped barren place of land covering an area of 1.3 sq.km. called Chhariya Bet [25°56'15" N, 70°20'15" E]. The conglomerate is most abundant in immediate neighbourhood of the northern part of Khadir Island, and adjoining the depression of the Great Rann of Kutch. This member consists of lenses and wedges of immature polymictic clast dominated breccio-conglomerate with subordinate grey coloured arkosic material as its matrix [Plate : 1]. The clasts include angular to subangular, rhomb-shaped or straight edged pebbles and cobbles or occasionally boulder sized pink coloured granitic [Plate : 1], dark coloured rhyolitic [felsite], trachytic and basaltic fragments with subordinate quarzites and gneissic pebbles. Occasionally the conglomerate is found associated with subarkosic sandstone packages. The overall clast composition is predominantly granite and felsite. The matrix of the conglomerate is mainly coarse sand and subarkosic sandstone. The CBCM exposes a total thickness of 25 m. Internally the conglomerate is generally disorganised with the clasts randomly oriented in a sandy matrix.

According to Biswas [1977], the poorly sorted polymictic conglomerate of Chhariya Bet initiates Mesozoic sedimentation in the region of Kutch. The CBCM conglomerate although recognised by him as a basal conglomerate, no visible contact with the underlying Precambrian basement rock was located anywhere around the Chhariya Bet region investigated by the author.

Plate : 1

[a] Extrabasinal polymitic breccio-conglomerate-Chhariya Bet

[b] Close up of rhomb-shaped polymictic clasts of Chhariya Bet

Biswas and Deshpande [1968] suggested two possible provenances for the conglomeratic material viz. Meruda Takkar Hill [24°7'30" N, 70°18'00" E] situated NE of Khadir and Kalinjar Hill of Nagar Parker [In West Pakistan]. These two hills comprise alkali syenite and syenitic granite rocks respectively. Another syenite mass further occurs in the same trend as Erinpura Granite in the Aravalli Range, is envisaged by the author as it could be the third provenance supplying clast material, to the depositional basin.

Two sets of joint patterns trending NE-SW and NW-SE [Plate : 2] respectively are confirmed in the Chhariya Bet region. Their cross-cutting relationship very often is seen to have produced rhomb-shaped clasts. Such clasts are very common in the conglomeratic rocks of Chhariya Bet.

[2] HADIBHADANG DUNGAR MEMBER [HDM] :

This member is designated from its type locality near the escarpment zone on the northern side of Hadibhadang Dungar [24°54'40" N, 70°21'35" E]. It exposes a total thickness of 126.5 m. having maximum east-west extension of 32 km. and marks the highest elevation of 294 m. from sea level in Khadir Island. The maximum development of the member however, is found in the central portion of the escarpment face of Khadir Island. It becomes thin towards east and west where some beds either disapper or get concealed beneath the escarpment scrap material. Hadibhadang Dungar Member displays characteristics of both the siliciclastic and calcareous

Plate : 2

[a] Two sets of joints pattern developed near SE of Chhariya Bet

[b] Polymictic breccio-conglomerate with intercalation of sub-arkosic sandstone - Chhariya Bet

sediments mixed in various proportions. The member can be unmistakebly recognised, on the basis of intraformational allochems [including skeletal fragments] and extrabasinal detrial angular to subangular terrigenous quartz grains and subordinate felspar and mica flakes, which form the bulk of its sediments. On the basis of such dominating factors different sedimentation units are assigned to the member. These include : [i] greyish white to pale yellow, medium grained bioclastic conglomerate, [ii] thinly-bedded yellowish brown **Corbula-Gervillia** rich sandy limestone, [iii] medium to coarse grained [some times gritty], subarkosic sandstone, [iv] massive, greyish white to pinkish white coloured subarkosic sandstones, [v] yellowish brown slightly hard and compact bioclastic limestone, [vi] greyish white to buff coloured calcarenaceous sandstone, and [vii] planer - cross-bedded subarkosic sandstones and thick shales.

In most of these units paleocurrent directions S35°W changing due west are confirmed on the basis of cross-bedding structures in the field. All such evidences further support the north-east and east provenance of the extrabasinal detrital material.

Megafossils such as brachiopods, pelecypods, corals and echinoids are easily found while microfossil are rare and were located in only a few thin sections.

Except borings in the rocks, no other biogenic structures were found. Stratigraphic relationship with the underlying Chhariya Bet Member is difficult to be established as the contact zone of the

two members is almost completely overlain by a thick cover of Rann sediments. The upper contact of the member with the overlying Hadibhadang Pir Member is rather continuous.

On the basis of the **Corbula lyrata** and **Gervillia sp.** occurrences, Bathonian age has been assigned to the rocks comprising the HDM by Cox [1940].

[3] HADIBHADANG PIR MEMBER [HPM] :

The name is derived from 'Hadibhadang Pir' [24°53'40" N, 70°22'25" E], a locality north of which the main exposure of the member is seen [especially along the N-S and E-W flanks]. It comprises a total thickness of 45.1 m. and incorporates a wide range of sediment types viz., [1] yellowish brown hard and compact medium grained polymictic conglomerate with clasts of felsite, granite and sand-sized cherty quartz; [2] yellowish brown thinly bedded fine to medium grained oyster-bearing limestone; [3] fossiliferous limestone; [4] Calcarenaceous sandstone; and [5] locally developed intraformational oligomictic limestone conglomerate.

Bivalves, gastropods, oysters and belemnites are found predominanting this member. Vertebrate bone-fibre structures are observed with the polymictic limestone conglomerate bed. No primary sedimentary structures were found anywhere but many biogenic structures characterize the member and include **Chondrites, Ophiomorpha, Rhizocorallium, Planolites, Compaginatichnus,**

Cylindricum, Thalassinoides, Paleodictyon, Psammichnites etc.

The Hadibhadang Pir Member comprises three lithofacies namely sandy allochemic limestone facies, sandy intraformational conglomerate facies, and micritic sandstone facies. It shows conformable contacts with the underlying Hadibhadang Dungar Member and the overlying Ratnasar Calcareous Sandstone Member.

[4] RATNASAR CALCAREOUS SANDSTONE MEMBER [RCSM] :

The name to this member is derived from 'Ratnasar Talao', centrally located in the southern gentle dipping face of the Khadir Island. Nomenclature to the member is adopted following the classification scheme for mixed sediments by Jeffrey Mount [1985]. It comprises calcareous sandstone with clay nodules, thinly bedded brownish shale with plant stems, fine to medium grained calcareous sandstone; fossiliferous limestone, gypseous shale, Ochrous red sandstone, burrowed cross-bedded calcareous sandstone, and iron-rich sub-arkosic sandstone. The cummulative sediment thickness of the member is 19.4 m.

The RCSM is further grouped into four lithofacies based on Jeffrey Mount [1985] classification scheme for mixed sediments. These include [i] Micritic sandstone facies, [ii] subarkosic micritic sandstone facies, [iii] micritic mudstone facies, and [iv] Allochemic siltstone facies. Out of these, Micritic sandstone facies [MS] has repeated thrice in the vertical stratigraphical column.

No primary sedimentary structures are present but biogenic structures dominate. The member is once again deviod of any megafossil or microfossil content. The Ratnasar calcareous sandstone member is found to conformably overlie the Hadibhadang Pir Member and in turn conformably underlie the Chamwa Wandh Fossiliferous Limestone Member. Such a relationship is clearly seen in the section exposed near Ratnasar Talao in the central part of Khadir Island.

The important biogenic structures include **Cylindrichnus, Monocraterion, Skolithos.**

[5] CHAMWA WANDH FOSSILIFEROUS LIMESTONE MEMBER [CWFLM] :

The name of this member is derived from the Village Chamwa Wandh, NW of which the [CWFLM] rocks are well exposed. Good exposures are also seen northeast of Gadhada village, near the damsite. The sediments comprise yellow-red clay, gypsum bearing sub-bentonitic clay; khaki, silty shales; ammonoidal limestones; and pholadomya-bearing sandy limestone. In the field all these beds can be identified on the basis of abundance of unbroken shells of pholadomya and ammonites or by the bright variegated column of the clays. The rocks are characteristically brownish to reddish coloured in their appearance. The cummulative thickness of this member is 9 m. Following the classification scheme of Jeffery Mount [1985] three lithofacies namely, Sandy Allochemic Limestone Facies [SAL], Micritic Mudstone Facies [MM] and Micritic Claystone [MCL] can be reorganised in CWFLM.

The occurrence of pholadomya-rich sandy limestone exposure distinguishes this member with the overlying Gadhada Sandstone and underlying Ratnasar Calcareous Sandstone Member. Furthermore, in contrast to the above members it is also rich in megafossils of ammonites, tiny gastropods and echinoderm spines.

No physical or biogenic structures are observed in the rocks. Exceptionally, occrrencce of the pseudotrace fossil namely Rivularites was observed in khaki shales of CWFLM.

[6] GADHADA SANDSTONE MEMBER [GSM] :

The definition of this member is derived from the centrally located village of Gadhada on Rapar-Dhoravira connecting road [23°52'06" : 70°22'30"]. Here the rocks are well exposed on both sides of the road. The presence of GSM can be marked in the field by the presence of dark reddish sandstone beds completely lacking Vegetation Cover. The member is widely developed and its maximum north-south and east-west coverage can be traced practically all over the Khadir Island region.

A number of stratigraphic sections were measured by the author, in order to gain maximum information from all such exposures. In most of the places the rocks are found gently dipping and become more or less horizontal as younger beds are approached. In all thirty four beds have been recognised in this member by the author. The lithographic unit as a matter of fact include in all six

lithofacies which constitutes almost half of the total lithofacies types recognised in the entire Khadir Island.

All the six lithofacies types are variously named as : Sandy Allochemic Limestone Facies, Sub-arkosic Micritic Sandstone Facies, Micritic Mudstones Facies, Micritic Sandstones Facies, Current-rippled Micritic Sandstone-shale Facies, and Wave-rippled sandy Allochemic Limestone Facies.

The Gadhada Sandstone Member has its lower distinct contact with Chamwa Wandh Calcareous Sandstone Member while an upper inferred contact with overlying Ganeshpur Calcareous Sandstone Member. Cummulative thickness of the member is 61.8 m. The maximum observed thickness is found at north of Janan.

Most of the sediments in Gadhada Sandstone Member are of 'mixed' origin. These, very often exhibit various types of primary sedimentary structures such as planer tabular cross-bedding, hummocky cross-stratification, symmetrical ripple marks, wave-ripple marks etc. The paleocurrent directions vary from N18°W to west.

The GCM is mainly characterized by the development of various types of trace fossil genera. Cheif amongst these include species of **Skolithos**, **Ophiomorpha**, **Arenicolites**, **Thalasinoides**, **Planolites**, **Palaeophycus**, **Phycodes**, **Palecypodichnus**, and **Rhizocoralium**. At some places the beds are completely bioturbated by the abundance of **Skolithos**, **Ophiomorpha** and **Phycodes** burrows.

The distinct corbula-bearing sandy limestone beds are very conspicuous in GSM. Inner portions of two intact shell valves of such pelecypods are often found calcified giving rise to eye-shaped white spots in the background of yellowish brown hard compact limestone [Plate : 3].

[7] GANESHPUR CALCAREOUS SANDSTONE MEMBER [GCSM] :

The name Ganeshpur is assigned to the member from its characteristic outcrop exposure near the Ganeshpur Village. The Ganeshpur Calcareous Sandstone Member underlie the Bambanka Member and overlie the Gadhada Sandstone Member. The east-west extension of this member is comparatively limited in contrast to the Godhada Sandstone Member. The cummulative thickness of this member is 20.3 m. As compared to the underlying gently dipping Gadhada Sandstone Member, Ganeshpur Calcareous Sandstone Member is deposited more or less on a horizontal surface. This member is characterized by varied sedimentary units such as fossiliferous calcareous sandstone; **Ophiomorpha**-bearing medium grained calcarenaceous sandstone; siltstone; wave-ripple fossiliferous limestone, purplish fossiliferous limestone; burrowed ferruginous shale with clayey sandstone; rippled sandstone; cross-bedded sandstone and ferruginous sandstone. The Ganeshpur Calcareous Sandstone Member can be differentiated with the underlain Gadhada Sandstone Member on the basis of its greater marine influence revealed by fossils contents in it.

Plate : 3

Development of "Bird-eye" structure on Shelly Sandy Limestone Subfacies of Gadhada Sandstone Member

The member on the basis of the mixed siliciclastic-carbonate properties is further divided into six lithofacies. These includes Sandy Allochemic Limestone Facies, Micritic Mudstone Facies, Current-rippled Micritic Sandstone-Shale and Wave-Rippled Sandy Allochemic Limestone Facies.

Both primary sedimentary and biogenic structures are found in the rocks of this member. Sedimentary Structure such as Cross-bedding show their average paleocurrent directions towards S22°W. Ripple marks indicate current direction towards SE.

Many biogenic structures such as **Ophiomorpha, Skolithos, Berguaeria** etc. are recognised and interpreted with respect to the GCSM.

[8] BAMBANKA MEMBER [BM] :

The extreme southernly and southeasternly occurring rocks of Khadir Island comprise Bambanka Member. The name is derived from the Bambanka village [24°48'35" N, 70°20'5" E]. Bambanka Member forms the youngest member of the Mesozoic stratigraphic sequence in Khadir Island. Good exposures of BM are found in NE, East and South-East of Bambanka village. Cummulative thickness of the rock is 12.8 m. BM conformably overlies Ganeshpur Calcareous Sandstone Member and underlies brownish red to brick-red Tertiary ferruginous sediments. On the basis of varied sediments, four lithofacies have been recognised for this member namely; Sandy Allochemic Limestone Facies; Micritic Mudstones Facies; Sandy Intraformational Conglomerate Facies; and Micritic Sandstone Facies.